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FINAL TECHNICAL MEMORANDUM STATISTICAL EVALUATION OF ANOMALY SELECTION FOR INTRUSIVE INVESTIGATION AT UNEXPLODED ORDNANCE 20 (UXO 20) NSWC INDIAN HEAD MD

10/8/2014

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Statistical Evaluation of Anomaly Selection for Intrusive Investigation at UXO 20, Naval Support Facility Indian Head, Indian Head, Maryland

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Introduction

This technical memorandum presents the digital geophysical mapping (DGM) findings and results of the follow-up statistical analysis to calculate the number of anomalies to be intrusively investigated at UXO 20 at the Naval Support Facility Indian Head (NSF-IH) in Indian Head, Maryland. CH2M HILL prepared this document under the Department of the Navy, Naval Facilities Engineering Command (NAVFAC), Washington, Comprehensive Long-Term Environmental Action Navy 1000 Program, Contract N62470-08-D-1000, Contract Task Order 0088, for submittal to NAVFAC Washington, NSF-IH, the U.S. Environmental Protection Agency, and the Maryland Department of the Environment.

The objective of the DGM was to identify the lateral extent of geophysical anomalies that may be indicative of potential munitions and explosives of concern (MEC)/material potentially presenting an explosive hazard (MPPPEH) at the site. The fieldwork was conducted in accordance with the *Final Remedial Investigation Work Plan for UXO 20 – Safety Thermal Treatment Plant, Naval Support Facility Indian Head, Indian Head, Maryland* (herein referred to as the Work Plan; CH2M HILL, 2012). Background information, site history, and the conceptual site model are also presented in the Work Plan. Figures follow the "References" section of this technical memorandum.

Digital Geophysical Mapping

DGM of UXO 20 was conducted on May 1, 2014. A detailed description of all activities in support of the DGM survey will be presented in a Remedial Investigation report to be prepared after the anomaly intrusive investigation; these details are not presented in this technical memorandum. The total acreage mapped was 0.53 acre of the approximate 1-acre site because of high water or dense vegetation along the shoreline, which prevented access with the DGM system. The DGM survey was conducted using a person-portable Geonics, Ltd. EM61-MK2 time domain electromagnetic induction sensor. Positioning was accomplished using a combination of real-time kinematic global positioning system and fiducial positioning referenced to surveyed stakes along gridlines.

The geophysical anomaly identification approach is described in the Geophysical Investigation Plan, which is appended to the Work Plan. A threshold of 3 millivolts was selected for anomaly identification. Anomalies in the DGM data caused by known cultural features, such as signs, fences, and pipes, were not included in the statistical evaluation. The anomalies identified during the DGM survey are depicted on Figure 1. A total of 507 point-source targets were identified. Of the total target count, 2 anomalies were related to quality

control (QC) seed items, and 26 anomalies were associated with known or suspected cultural objects. Therefore, a total of 479 detected targets were associated with metallic items potentially indicative of MEC/MPPEH in the subsurface.

Statistical Selection of DGM Anomalies for Intrusive Investigation

The Estimating a Proportion method was used to calculate the number of randomly selected DGM anomalies that would need to be intrusively excavated to estimate, with a 95 percent confidence level and ± 5 percent sampling error, the proportion of munitions-related to non-munitions-related items within the population of anomalies detected at UXO 20.

Estimating a Proportion Method

When a population size is large or unknown, the necessary sample size of DGM anomalies to be intrusively investigated can be estimated using the following statistical sample size formula:

$$n_0 = \frac{Z_\alpha^2 pq}{e^2}$$

Z_α	=	desired confidence level
p	=	proportion of DGM anomalies classified as munitions-related
q	=	proportion of DGM anomalies classified as non-munitions-related (q = 1-p)
e	=	acceptable margin of error for proportion being estimated
n_0	=	statistical sample size for a large population

To conservatively estimate the variance of proportional variables (munitions-related or non-munitions-related), pq (in the equation above), a population proportion of 50 percent (p=0.5) is estimated to maximize the variance, and subsequently maximize the sample size. Using a z-statistic for a 95 percent confidence level (Z_α=1.96) and a margin of error of 5 percent (e=0.05), the solution for n_0 becomes:

$$n_0 = \frac{Z_\alpha^2 pq}{e^2} = \frac{1.96_\alpha^2 (0.5)(0.5)}{0.05^2} = 384$$

A maximum of 384 randomly selected DGM anomalies is estimated for classifying, with 95 percent confidence level and ± 5 percent sampling error, the proportion of munitions-related to non-munitions-related DGM anomalies in a large or unknown population.

Following the estimation of the population size above, the following finite population correction can be used to reduce the number of anomalies required to obtain the same confidence level:

$$n_1 = \frac{n_0}{1 + \left(\frac{n_0}{N}\right)}$$

n_1 = adjusted statistical sample size for a finite population
n_0 = statistical sample size for a large population
N = size of the population (number of DGM anomalies)

The finite population correction equation used a random number selector process and excluded the 28 anomalies related to QC seed items and known and suspected cultural objects. This means that of the 507 total anomalies, 479 anomalies were used as “N” in the equation to calculate the finite population correction:

$$n_1 = \frac{n_0}{1+\left(\frac{n_0}{N}\right)} = \frac{384}{1+\frac{384}{479}} = 213.2$$

The results of this calculation for various population sizes at a 95 percent confidence level are shown on Figure 2. The number of anomalies required for the intrusive investigation at UXO 20 is shown as a dot in Figure 2.

The Estimating a Proportion Method indicates that intrusively investigating 213 anomalies would provide a statistically derived estimate of the distribution of munitions-related to non-munitions-related items to a 95 percent confidence level within ± 5 percent sampling error. From the population of 479 anomalies, the 213 anomalies needed for intrusive investigation will be selected using a random-number generator.

Although not part of the statistical calculation, the QC seeds will be added to the UXO 20 dig list as a means of providing ongoing QC during the intrusive investigation. Therefore, adding the 2 anomalies for the QC seeds results in a total of 215 anomalies for intrusive investigation at UXO 20. The locations of these 215 anomalies are presented on Figure 3.

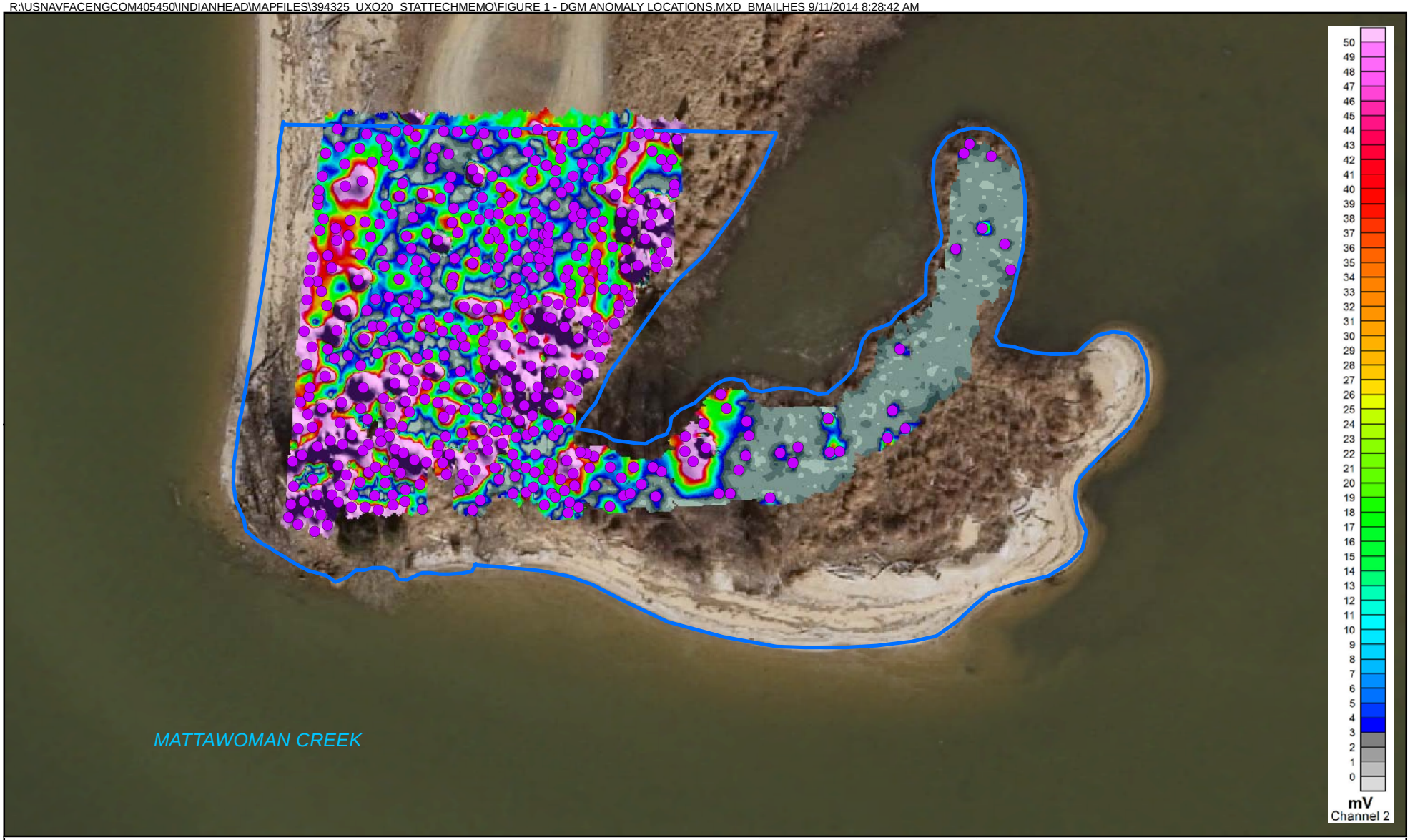
Conclusion

A total of 507 geophysical targets were selected from the DGM at UXO 20. Of these, 479 targets were identified as potentially representing MEC/MPPEH in the subsurface. The Estimating a Proportion Method was used to calculate the number of anomalies necessary for a statistically derived characterization of the proportion of munitions-related items to non-munitions related items at UXO 20. Using this statistical tool, 213 anomalies were calculated for intrusive investigation to characterize the anomaly population. The total dig count would be 215 after inclusion of the QC seeds in the final dig list.

References

CH2M HILL, 2012. *Final Remedial Investigation Work Plan for UXO 20 – Safety Thermal Treatment Plant, Naval Support Facility Indian Head, Indian Head, Maryland.* November.

R:\USNAVFACENGCOM405450\INDIANHEAD\MAPFILES\394325_UXO20_STATTECHMEMO\FIGURE 1 - DGM ANOMALY LOCATIONS.MXD BMAILHES 9/11/2014 8:28:42 AM



Legend

- Anomalies Identified During Survey
- Approximate Site Boundary

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0 25 50
Feet

Note:
Digital geophysical mapping (DGM) was performed in one event on May 1, 2014 over 0.53 acres.

Figure 1
Digital Geophysical Mapping Anomaly Locations
Statistical Evaluation of Anomaly Selection for Intrusive Investigation at UXO 20
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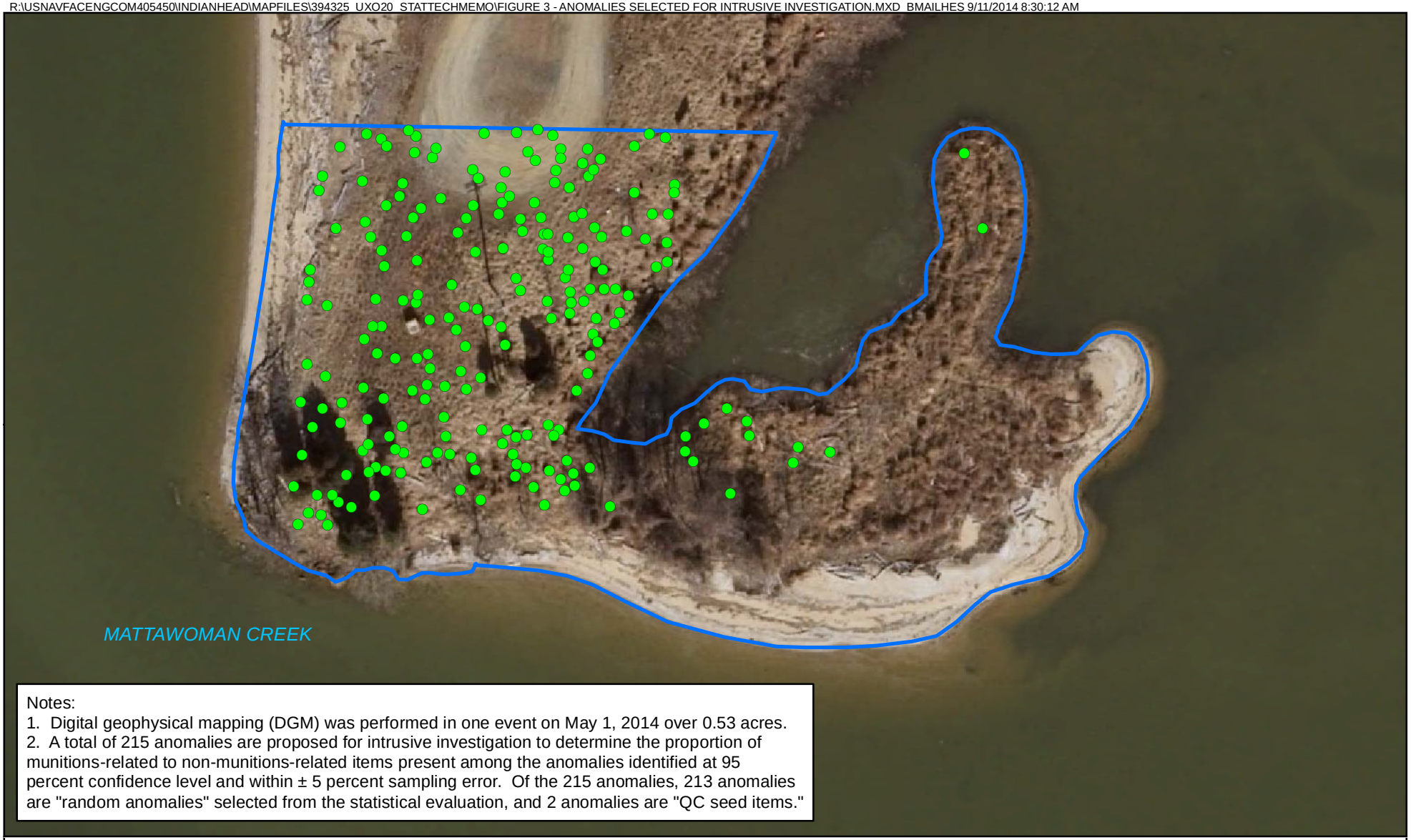
Figure 2
Sample Size Estimate
Statistical Evaluation of Anomaly Selection for Intrusive Investigation at UXO 20
NSF-IH, Indian Head, Maryland

R:\USNAVFACENGCOM405450\INDIANHEAD\MAPFILES\394325_UXO20_STATTECHMEMO\FIGURE 3 - ANOMALIES SELECTED FOR INTRUSIVE INVESTIGATION.MXD BMAILHES 9/11/2014 8:30:12 AM



Notes:
1. Digital geophysical mapping (DGM) was performed in one event on May 1, 2014 over 0.53 acres.
2. A total of 215 anomalies are proposed for intrusive investigation to determine the proportion of munitions-related to non-munitions-related items present among the anomalies identified at 95 percent confidence level and within ± 5 percent sampling error. Of the 215 anomalies, 213 anomalies are "random anomalies" selected from the statistical evaluation, and 2 anomalies are "QC seed items."

Legend
- Anomalies for Intrusive Investigation
- Approximate Site Boundary

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Feet

Figure 3
Anomalies Selected for Intrusive Investigation
Statistical Evaluation of Anomaly Selection for Intrusive Investigation at UXO 20
NSF-IH, Indian Head, Maryland

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